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Rehabilitation after resurfacing hip arthroplasty: cost-utility analysis alongside a randomised controlled trial.

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Abstract

Objective

To assess the costs, effects, and cost-utility of an accelerated-physiotherapy programme versus a standard-physiotherapy programme following resurfacing hip arthroplasty.

Design

A cost-utility analysis alongside a randomised controlled trial.

Setting

A United Kingdom National Health Service hospital and patients' homes.

Subjects

Eighty male resurfacing hip arthroplasty patients randomised post-procedure to one of the two programmes.

Interventions

The accelerated-physiotherapy programme commenced in hospital with patients being fully weight-bearing, without hip precautions, and following a range of exercises facilitating gait re-education, balance and lower-limb strength. Standard-physiotherapy commenced in hospital but hip precautions were used and exercises were only partially weight-bearing. In both groups, patients continued with their exercises at home for an eight-week period.

Main Measures

Data on healthcare contacts were collected from patients out to 12 months and costed using unit costs from national sources. Information was also collected on patients' costs. Health-related quality of life was measured using the EuroQol EQ-5D questionnaire and used to estimate quality adjusted life years to 12 months. Mean costs and quality adjusted life years for each trial arm were compared.

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Results

On average, the accelerated-physiotherapy programme was less expensive (mean cost difference -£200; 95% confidence interval: -£656 to £255) and more effective (mean quality adjusted life years difference 0.13; 95% confidence interval: 0.05 to 0.21) than standard-physiotherapy and had a high probability of being cost-effective.

Conclusions

From the National Health Service perspective, an accelerated-physiotherapy programme for male patients undergoing RHA is very likely to be cost-effective when compared to a standard-physiotherapy programme.

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Keywords

Cost-utility, randomised controlled trial, physiotherapy, rehabilitation, hip arthroplasty.

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Introduction

We previously demonstrated in a randomised controlled trial of young male patients who have undergone hip resurfacing arthroplasty, that an accelerated physiotherapy programme led to a measurable benefit in clinical outcomes (range of motion, hip flexion and hip extension) and quality-of-life at 12 months when compared with standard physiotherapy.[1] The study showed patients were able to tolerate and receive greater benefit from a less precautionary and more intensive approach to rehabilitation.

However, it remains uncertain whether such benefits are realised at an increased cost. Given the scarcity of health care resources, this requires further investigation before decisions can be made about providing such a service as part of the National Health Service in England and Wales.

To the best of our knowledge, no other studies assessing the cost-effectiveness of accelerated or intensive physiotherapy programmes following resurfacing hip arthroplasty have been published. In this paper we report the findings from a cost-utility analysis conducted alongside our aforementioned randomised controlled trial with a view to drawing conclusions about the likely cost-effectiveness of an accelerates physiotherapy programme following resurfacing hip arthroplasty.

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Methods

Patients referred to the National Health Service Nuffield Orthopaedic Centre in Oxford in the United Kingdom for primary resurfacing hip arthroplasty from 2009 to 2010 were assessed for inclusion into the study. Patients were excluded if they were listed for bilateral arthroplasty, minimally invasive surgery, or further lower limb joint surgery in the following 12 months, or were unable to provide informed consent.

A computer generated the randomisation sequence, using blocks of 20. Treatment allocation was concealed from two research physiotherapists, who were blinded to treatment allocation. The sequence was concealed in numbered envelopes and opened sequentially by an administrator, who informed the clinical physiotherapist of group allocation. The clinical physiotherapists – who worked independently to the research team, were trained to avoid the failure of blinding and concealment. Further details of the trial have been published elsewhere.[1]

The trial was powered to detect a four-point change on the Oxford Hip Score at 52 weeks post procedure.[11] Patients in each arm received twice daily programme-specific physiotherapy sessions until hospital discharge. In the conventional arm patients followed the physiotherapy programme used for total

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hip arthroplasty patients. Hip precautions were used and exercises were only partially weight bearing to help regain range of motion and included isometric strengthening exercises.[1] In the accelerated physiotherapy programme arm we did not require patients to follow the various 'hip precautions' used in the standard physiotherapy arm, such as not being allowed to flex hips more than 90° and not being allowed to cross legs and patients were fully weight bearing from the start of the programme in hospital. Exercises in this arm were wide ranging and included on-going gait re-education to increase walking distance, direction, and reduce reliance on aids, activities to increase the range of hip movement and lower limb strength, and balance training and weight bearing exercises. At hospital discharge, patients in each arm of the trial were given a booklet with guidelines on how to continue with their exercise programme at home for an 8-week period. accelerated physiotherapy programme patients received an additional rehabilitation session (at home or as an outpatient) two weeks after surgery.

A health economic evaluation, specifically a cost-utility analysis was designed as an integral part of the trial.[12]

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Costing

A United Kingdom National Health Service perspective was adopted for the costing component of the analysis, with costs expressed using 2014/15 United Kingdom £ Sterling. The costs incurred by the patients were also included in our analyses as a complementary perspective.

During the primary hospitalisation, patients in both arms received two physiotherapy sessions per day. Thereafter, the physiotherapy received by patients in the accelerated programme arm differed in terms of precautions and intensity from the physiotherapy received by patients in standard programme arm. Both programmes were assumed to consume equivalent amounts of physiotherapists time with the exception of the accelerated physiotherapy arm where patients received one additional physiotherapy session at two-weeks post-operation. Therefore, the costs of providing the rehabilitation programmes *per se* were not included in the analysis as they would cancel each other out when comparing costs across trial arms. However, we accounted for and costed the additional physiotherapist visit received by patients randomised to the accelerated physiotherapy programme. More details on the intervention were provided elsewhere.[1]

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At 6, 16, and 52 weeks, patients submitted study diaries they had been using to prospectively record contacts with the National Health Service and with private health practitioners. Each patient recorded data on the frequency of visits to general practitioners, practice nurses, outpatient clinics (surgical / non-surgical), physiotherapists and other health care professionals, and home visits from general practitioners, nurses and physiotherapists. The occurrence and duration of any hospital re-admissions (for reasons related to the hip and also for other non-hip related reasons) was recorded, as well as information on the frequency and types of visits to private health care practitioners, and on equipment usage (e.g. sock aids, crutches) and duration. When equipment usage was recorded at 16 weeks but had been discontinued by 52 weeks, usage was assumed to have continued for half of this 36-week period. Resource use data were costed using the unit costs shown in Table 1.

[please, insert table 1 here]

Health Outcomes

Patients completed the 3-level EuroQol EQ-5D questionnaire at baseline, 6, 16, and 52 weeks.[13] The EQ-5D is a generic health related quality of life instrument which contains questions on five domains: mobility, self-care, usual activities,

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pain/discomfort and anxiety/depression. Each domain has three levels - no problems, some problems and extreme problems.[13] Patients responses to the questionnaire provide a unique health state description which can then be converted into a single index score using a tariff estimated using data from a sample of the United Kingdom population.[14] The single index score is anchored at zero (reflecting death) and one (reflecting perfect health). Negative scores signify health states considered to be worse than death. A linear trend was assumed between a patient's scores at each time point, and the area under the resulting curve gave the number of quality adjusted life years experienced by that patient to 12 months. [15] Quality adjusted life years are a composite measure of health outcome combining morbidity and mortality associated with a disease or condition.

Statistical analysis

We assumed that the probability of data being missing depended on observed data and not on unobserved data (that is data were missing at random and could be predicted using other data collected during the trial).

Multiple imputation was used to impute these missing data.[16] Multiple imputation uses regression-based approaches to predict *m* values for each missing data cell and so accounts for the uncertainty in the imputation process itself, and enables

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all variables in the dataset (both complete and incomplete) to be used to predict the values of missing data cells.[16] Here, individual regressions were specified for each variable with missing data, and five values were imputed for each missing data cell, essentially creating five different datasets. Rubin's rule was used to summarise data across imputed datasets when calculating results.[16, 17] The approach accounts for the variance within imputed datasets as well as between imputed datasets.

When summarising resource use, costs, EQ-5D scores and quality adjusted life years for each trial arm, means and standard errors were used. When comparing between trial arms, mean differences and 95% confidence intervals (95% CI) around those differences were calculated. On account of the skewed nature of the data, non-parametric bootstrapping (using 5,000 replicates) was used to estimate the confidence intervals.[15]

The mean cost and quality adjusted life years differences were plotted as a single point on the cost-effectiveness plane, a two-dimensional figure with four quadrants representing all possible outcome combinations of cost and quality adjusted life years differences (i.e. accelerated physiotherapy programme costs more and is less effective than standard physiotherapy, costs more and is more

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effective, costs less and is less effective, and costs less and is more effective).[15] As the trial was not powered for cost-utility, uncertainty around the cost-utility result was examined using non-parametric bootstrapping which utilised sampling with replacement to simulate 5,000 pairs of mean cost and quality adjusted life years differences, which were also plotted on the cost-effectiveness plane. Each cost and quality adjusted life years pair has an associated incremental cost-effectiveness ratio (ICER), calculated by dividing the mean cost difference by the mean quality adjusted life years difference.[15] The ICER represents the change in costs required to gain one additional quality adjusted life year when moving from a conventional to a new therapy. A study's ICER is routinely benchmarked against the maximum acceptable ICER, which at £20,000 per quality adjusted life year is considered to represent society's maximum willingness to pay for a quality adjusted life year.[18] In this study, estimating the proportion of the bootstrapped cost and quality adjusted life years pairs with corresponding ICERs below £20,000 per quality adjusted life years allowed an estimate to be made of the probability that accelerated physiotherapy programme will be cost-effective when compared with conventional physiotherapy. Varying the maximum willingness to pay and each time re-calculating the proportion of plotted points with ICERs below this figure enabled the construction of the cost-effectiveness acceptability

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curve which indicates for varying levels of willingness to pay, the probability that accelerated physiotherapy programme will be cost-effective.[15]

All statistical analyses were performed using Stata SE v12.0 (StatCorp, College Station, TX, USA).

Sensitivity Analysis

To assess the robustness of results, extensive sensitivity analysis was performed using alternative values for the driver of cost (i.e. the number of hospitalisations) and for levels of health related quality of life in the accelerated physiotherapy programme arm. The number of hospitalisations in the accelerated physiotherapy programme arm was increased from the observed estimate in increments of 25% up to 100%. We also separately assessed the impact of health related quality of life experienced in the accelerated physiotherapy programme arm on our results by simulating 4 scenarios: 1) a reduction of the quality adjusted life years in the reference case by 15%, 2) a reduction of 7.5%, 3) an increment of 7.5% and 4) an increment of 15%. In scenarios (3) and (4), the maximum health gain was limited to 1 quality adjusted life year.

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A two-way sensitivity analysis combined all possible combinations of the alternative values used for the two parameters tested in the one-way analyses.

Results

Demographics

Eighty male patients were randomised post-surgery to an accelerated physiotherapy programme (n=40) or to a conventional physiotherapy programme (n=40). Figure 1 shows the flow of patients through the trial. [1,19]

[Please insert here figure 1]

Table 2 shows baseline characteristics for the 80 patients randomised. The two arms were similar at baseline across most of the clinical measures observed (for example range of motion) and for patient reported outcomes (for example Hip disability and Osteoarthritis Outcome Score), with the exception of body mass index (p=0.019) and flexors muscle strength (p=0.045). The accelerated physiotherapy programme arm had a lower body mass index than the control arm (-1.8 Kg m^{-2}) and a reduced strength of the flexors (2.7 NM).

[please, insert here table 2]

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Costs

Twenty-two and a half percent of trial data were missing on resource use and were imputed using multiple imputation. Table 3 shows mean per patient resource use and costs for each trial arm. In the 12 months following resurfacing hip arthroplasty, patients in the accelerated physiotherapy programme arm made noticeably fewer visits to surgeons (0.62 v 1.05, p=0.16) and to physiotherapists (0.94 v 2.32, p<0.05) than their counterparts in the standard physiotherapy arm. Additionally, accelerated physiotherapy programme patients on average, spent less time in hospital (for both hip and non-hip related reasons) but did record more home visits from physiotherapists (0.71 v 0.11, p<0.05), which is not unexpected given the additional physiotherapy contact (which could be home or clinic-based) scheduled for these patients at two weeks post-surgery.

Considering all National Health Service contacts, mean (standard error) total costs for the National Health Service were £504 (£104) per patient in the accelerated physiotherapy programme arm and £706 (£187) in the standard physiotherapy arm, giving a mean cost difference favouring accelerated physiotherapy programme of -£200 (95% CI -£656 to £255, p=0.35). We also observed a small mean difference in patient costs favouring the accelerated physiotherapy programme arm (see Table 3).

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1

2 [***Insert here table 3***]

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Health Outcomes

We imputed the ten percent of EQ-5D data that were missing. Figure 2 shows health related quality of life improved in both arms between baseline and 6 weeks, and whilst further improvements were seen in the accelerated physiotherapy programme arm at 16 and 52 weeks, EQ-5D scores in the standard physiotherapy arm remained relatively stable from 6 weeks onwards. At 52 weeks mean (standard error) EQ-5D scores were 0.91 (0.03) in the accelerated physiotherapy programme arm and 0.73 (0.05) in the standard physiotherapy arm, giving a statistically significant difference favouring accelerated physiotherapy programme of 0.18 (95% confidence intervals 0.07 to 0.29, p=0.002).

There were no deaths during the trial. Estimating quality adjusted life years as the area under each patient's EQ-5D health related quality of life profile to 12 months showed that accelerated physiotherapy programme patients on average experienced 0.84 (0.02) quality adjusted life years over the 12-month period and standard physiotherapy patients experienced 0.71 (0.03) quality adjusted life years. The mean quality adjusted life years difference of 0.13 (95% confidence intervals 0.05 to 0.21, p=0.002) favoured the accelerated physiotherapy programme and was statistically significant.

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[please insert here figure 2]

Cost-effectiveness

Analysis showed that on average and when compared with standard physiotherapy, the accelerated physiotherapy programme was associated with cost savings to the National Health Service of £200 per patient and a significant gain of 0.13 quality adjusted life years. Figure 3 shows the plot of the 5,000 bootstrapped cost and quality adjusted life years difference pairs on the cost-effectiveness plane and shows that the majority (86%) fall within the South-East quadrant on the plane where the accelerated physiotherapy programme is more effective and less costly than standard physiotherapy. A proportion of points do however fall within the North East quadrant suggesting there is a potential for accelerated physiotherapy programme to be more effective but also more costly than standard physiotherapy. None of these points however produced an ICER (calculated by dividing the difference in cost by the difference in quality adjusted life years) greater than £10,000, which is below the value of £20,000 which is thought to represent society's maximum willingness to pay for a quality adjusted life year in the United Kingdom. Figure 4 shows for the reference case, the probability that accelerated physiotherapy programme is cost-effective when

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compared to standard physiotherapy, for different values of maximum willingness to pay for a quality adjusted life year. Assuming the maximum willingness to pay per quality adjusted life year is £20,000, the accelerated physiotherapy programme is cost-effective – namely the cost-effectiveness probability is one.

[please insert here figure 3]

[please insert here figure 4]

Sensitivity analysis

Among all the assessed scenarios reported in Table 4, none changed the resulting cost differences in terms of statistical significance. Our cost results were sensitive only to more extreme assumptions; for example doubling the hospitalisation cost reduced the mean cost difference from -£200 in favour of accelerated physiotherapy programme to -£4 (95% confidence intervals: -£554 to £546). Nevertheless, the probability that accelerated physiotherapy programme is cost-effective for willingness to pay values above £5,000 per quality adjusted life year was unaffected by inflating the number of hospitalisations in the accelerated physiotherapy programme arm (figure 4, panel a). On the other hand, quality adjusted life year results were more sensitive to changes. Reducing the quality adjusted life years of accelerated physiotherapy

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programme patients by 7.5%, the between arm difference was no longer significant (0.07 QALYs; 95% confidence intervals -0.01 to 0.14). The probability that accelerated physiotherapy programme is cost-effective for willingness to pay values above £5,000 per quality adjusted life year however remained virtually unaltered for most of the quality adjusted life year scenarios (figure 4, panel b). Only reducing the quality adjusted life years in the accelerated physiotherapy programme arm by 15% resulted in higher uncertainty as to whether accelerated physiotherapy programme is cost-effective (figure 4, panel b).

Table 5 combined the values used in the one-way sensitivity analyses presented in Table 4 and shows the probabilities that the accelerated physiotherapy programme is cost–effective assuming the maximum willingness to pay per quality adjusted life year is £20,000. These probabilities are calculated by identifying the proportion of all bootstrap replicates giving an incremental cost-effectiveness ratio lower than £20,000 per quality adjusted life year, with a value of 1 indicating 100% of points fall below this threshold. A potential decrement in the health related quality of life of the accelerated physiotherapy programme patients by 15% would reduce the probability of it being cost-effective to a range between 0.61 (accelerated physiotherapy programme hospitalisation rate: reference case) and 0.52 (accelerated physiotherapy programme hospitalisation

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rate: +100%), as shown in Table 5. The results *of the* sensitivity analysis suggested that accelerated physiotherapy programme is very likely to be cost effective, unless patients' would experience a substantial lower health related quality of life than our estimates (i.e. 15% decrement in health related quality of life).

[insert here table 4 and table 5]

Discussion

The current economic evaluation showed that an accelerated physiotherapy programme is likely to be a cost-effective alternative to standard physiotherapy following resurfacing hip arthroplasty in young male patients. Total National Health Service costs incurred during the 12 months following the resurfacing hip arthroplasty were lower in the accelerated physiotherapy programme arm by an average of £200, although this cost difference did not achieve statistical significance.

The lower cost in the accelerated physiotherapy programme arm was primarily due to patients needing to spend less time in hospital than their standard physiotherapy counterparts during the 12-month study period. Whilst this could

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have been because accelerated physiotherapy programme patients were on average mobilised quicker and may have been less susceptible to complications (the reduction in hip-related hospital admissions with accelerated physiotherapy accounted for almost half of the total cost saving at (-£93)), one must acknowledge that hospital re-admission costs in both groups were generally very low and this finding may have been a chance occurrence.

This study showed that when compared with standard physiotherapy, patients who had received accelerated physiotherapy on average reported significantly better health related quality of life on the EQ-5D questionnaire at 12 months after resurfacing hip arthroplasty and gained a significantly greater number of quality adjusted life years over the study time horizon. Such findings are intuitive given the clinical results of the trial which showed that the accelerated physiotherapy programme significantly improved clinical outcomes, including levels of hip disability, osteoarthritis and activity ability.[1] It would appear that with accelerated physiotherapy, faster mobilisation, a reduction in limitations due to range of motion, and improved confidence due to absence of hip precautions, all translate into a better sense of overall wellbeing for patients.

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The number of studies focusing on the effects of different forms of rehabilitation following resurfacing hip arthroplasty is limited. Indeed, the trial on which this economic evaluation was based was included in a recent systematic literature review, which identified only three other papers, one based on a case-series and two reporting individual case studies.[5] Therefore, the comparison of our results with those from the literature is problematic.

Edlin et al. did assess the cost-effectiveness of resurfacing hip arthroplasty versus total hip arthroplasty and in doing so, reported the cost of standard care rehabilitation after resurfacing hip arthroplasty , permitting a comparison with the cost results reported here for the standard physiotherapy arm.[20] The patients involved in the Edlin et al. study were also recruited in the United Kingdom and the analysis was performed from a United Kingdom National Health Service perspective. On average, patients in the Edlin study had a higher cost per patient (at 12 months follow up) than seen here: £942 versus £705.[20] This difference, although not substantial could be attributable to demographic characteristics and the worse health status of the patients enrolled in the Edlin et al study. The mean EQ-5D score recorded at baseline (0.31 (95% CI: 0.22 to 0.39)) was lower than the corresponding score we report here, 0.53 (95% CI: 0.45 to 0.61).[20]

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Also, 37% of individuals recruited by Edlin et al. were women, who were shown to have higher expenses than their male counterparts. Poorer health could therefore have led to greater requirements for healthcare and thus higher costs. Interestingly, both studies identified hospitalisation as the major cost driver at 12 months. The inpatient cost in the resurfacing hip arthroplasty arm of that study accounted for almost 50% of the total cost (£942) excluding the cost of primary operation.[20] Similarly, the hospitalisation cost in our study accounted for 48% of the total cost (£705) in the standard physiotherapy arm.

There are several limitations that should be considered when interpreting the results of the current study. Firstly, our results are based on patients receiving metal-on-metal resurfacing hip arthroplasty. The number of patients accessing to metal-on-metal resurfacing hip arthroplasty is currently limited mainly because of the recent concern surrounding metal-on-metal side-effects (e.g. pseudotumors and elevated metal ions levels).[21] Nevertheless, we still believe our findings could be applicable to other patient populations including those undergoing large-diameter resurfacings (e.g. ceramic-on-ceramic) and the general hip arthroplasty population. However, future studies should confirm our findings in these alternative patient groups.

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Secondly, the time horizon of our analysis is limited to 12 months of follow-up. Although the short time period of this study might exclude costly events (such as revision following resurfacing hip arthroplasty), this analysis focused on the post-operative recovery of function.

Thirdly, this trial enrolled exclusively male patients, limiting the applicability of our study to a broader population. According to the findings from Edlin et al, females incurred higher costs and received a smaller health related quality of life benefit than men after standard physiotherapy.[20] Using the sensitivity analysis presented in this paper, we can contemplate the potential implications for the results had women been included in our study. Scenario analyses showed that even when costs were increased and the quality adjusted life year gain was reduced, the accelerated physiotherapy programme remained the cost-effective alternative in all scenarios except those in which the quality adjusted life year gain with accelerated physiotherapy was reduced by a maximum of 15% (Table 5). Additionally, the sensitivity analysis results also confirmed the impact of changes to the hospitalisation cost on overall results is marginal when compared to the influence of changes to HRQoL.

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Finally, our analysis used nationally representative unit costs to value resource use data from a single study centre. Whilst we acknowledge that it would have been possible to source and use locally available unit costs, ultimately, we felt this approach would diminish the generalizability of the study findings and its usefulness to readers in different geographical locations.

This study provides the first reported evidence on the cost-effectiveness of an accelerated physiotherapy programme when compared with standard physiotherapy for male patients who have undergone resurfacing hip arthroplasty. Our findings suggest that an accelerated physiotherapy programme is likely to be a cost-effective alternative to standard physiotherapy following resurfacing hip arthroplasty, with the results being largely driven by improvements in health related quality of life reported by accelerated physiotherapy programme patients during the course of the study. Therefore, the adoption of a more intense rehabilitation programme is not only likely to improve the clinical and quality of life outcomes of patients following resurfacing hip arthroplasty, but it also may represents good value for money for the National Health Service.[1]

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Clinical Messages

An accelerated physiotherapy programme significantly improves health-related quality of life and may reduce costs in young resurfacing hip arthroplasty male patients.

A tailored protocol for rehabilitation in resurfacing hip arthroplasty patients is very likely to offer a cost-effective use of resources (the probability of it being cost-effective at a willingness to pay value of £5,000 per quality adjusted life year is one).

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Author contributions: FF performed the data analysis and produced a first draft of the manuscript. HC designed the analysis plan and supervised the data analysis. KB was the primary investigator on the resurfacing hip arthroplasty Trial, was involved in the study design and the interpretation of the results. All authors were involved in reviewing and editing the final manuscript.

Competing interests: The authors declare that there are no conflicts of interest.

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Table 1. Unit costs used in the analysis (United Kingdom £ 2014/15)

Resource unit	Unit price	Source
Home Visits		
General practitioner	£100	PSSRU[22]
Nurse	£38	PSSRU[22]
Physiotherapist	£50	PSSRU[22]
Other*	£59.5	PSSRU[22]
Health Care Practice Visits		
General practitioner	£24	PSSRU[22]
Nurse	£11	PSSRU[22]
Surgeon	£115	National schedule of reference costs[23]
Doctor – Other	£135	National schedule of reference costs[23]
Physiotherapist	£36	PSSRU[22]
Other*	£64.2	PSSRU[22]
Private Health Care Visits		
General Practitioner	£24	PSSRU[22]
Nurse	£11	PSSRU[22]
Physiotherapist	£45	BUPA[24]
Occupational therapist	£45	BUPA[24]
Osteopath	£52.80	BUPA[24]
Chiropractor	£55	UK Healthcare Centre[25]
Other*	£36	BUPA[24]
Hospitalization day		
Not related to hip	£345	National schedule of reference costs[23]
Related to hip	£316	National schedule of reference costs[23]
Equipment†	£0.61	PSSRU[22]

Acronyms: Personal Social Service Research Units (PSSRU), United Kingdom (UK), British united provident association (BUPA).
* E.g. Types of other visits were not specified and so when costing, we use a unit cost averaged across specified types of contacts.
† Equipment includes: crutches, sticks, sock aid, raised toilet seat, shoe horn, helping hand, bath board, chair/bed raiser and other. Equipment unit price are reported as cost per week, but sock aid and shoe horn as item cost.

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Table 2. Demographic characteristics

Baseline characteristics	Standard Programme (n=40)	Accelerated Programme (n=40)	p value
Age at operation (years), median (IQR)	55.8 (49.0,61.0)	55.8 (49.1,59.0)	0.535
BMI (kg/m^2), average (s.d.)	29.2 (3.8)	27.4 (2.9)	0.019
Preoperative OHS, average (s.d.)	27.1 (8.5)	25.0 (7.8)	0.253
Preoperative HOOS, average (s.d.)	50.6 (15.3)	47.3 (14.1)	
Preoperative rescaled HOOS, average (s.d.)			
Total	50.6 (15.3)	47.3 (14.1)	0.317
Symptoms	51.7 (19.5)	46.9 (18.3)	0.261
Stiffness	45 (19.4)	44.7 (16.2)	0.938
Pain	51.6 (15.4)	47.3 (13.9)	0.185
Function - daily living	59.3 (16.8)	54.2 (17.2)	0.183
Function - sports activities	35 (20.2)	32.0 (19.6)	0.506
Quality of life	30 (16.3)	34.2 (19.6)	0.236
Preoperative UCLA activity score, median (IQR)	4.5 (3,6)	5.5 (3.5,7)	0.083
ROM Flexion (degrees), average (s.d.)	85.3 (17.1)	82.2 (19.3)	0.449
ROM Extension (degrees), average (s.d.)	16.2 (13.1)	18.4 (14.9)	0.486
ROM Abduction (degrees), average (s.d.)	19.2 (7.3)	18.9 (9.7)	0.898
Muscle strength Flexion (degrees), average (s.d.)	16.8 (6.7)	14.1 (4.9)	0.045
Muscle strength Abduction (degrees), average (s.d.)	13.2 (5.4)	12.2 (4.4)	0.339
Muscle strength Extension (degrees), average (s.d.)	13.9 (5.2)	12.0 (5.1)	0.106
EQ5D utility at baseline average (s.d.)	0.53 (0.26)	0.49 (0.30)	0.529
EQ-5D-3L Visual Analogue Scale, average (s.d.)	64.3 (20.50)	63.95 (20.00)	0.939

Acronyms: Interquartile range (IQR), Body Mass Index (BMI), standard deviation (s.d.), Oxford Hip Score (OHS), Hip disability and Osteoarthritis Outcome Score (HOOS), University of California, Los Angeles (UCLA) activity score, range of motion (ROM), EuroQol 5 dimension three level (EQ-5D-3L)

For Peer Review

Table 3. Follow-on health service and private resource use and costs (2014/15 United Kingdom £) to 12 months

Resource Item	Standard Programme n=40	Accelerated Programme n=40	Standard Programme n=40	Accelerated Programme n=40	
	Mean (s.e.) resource use per patient	Mean (s.e.) resource use per patient	Mean (s.e.) cost per patient	Mean (s.e.) cost per patient	Mean cost difference (95% CI)
Home Visits From					
General Practitioner	0.04 (0.03)	0.08 (0.08)	£4.00 (£3.47)	£8.00 (£7.67)	£4.00 (-£12.60 to £20.60)
Nurse	0.20 (0.17)	0.41 (0.17)	£7.60 (£6.57)	£15.39 (£6.47)	£7.8 (-£11.17 to £26.75)
Physiotherapist	0.11 (0.08)	0.71 (0.09)	£5.50 (£4.21)	£35.25 (£4.69)	£29.75 (£17.92 to £41.58)†
Other	0.1 (0.07)	0.06 (0.04)	£5.95 (£3.91)	£3.57 (£2.61)	-£2.38 (-£11.85 to £7.09)
Patient Visits To					
General Practitioner	1.21 (0.27)	0.88 (0.20)	£28.92 (£6.42)	£21.12 (£4.86)	-£7.8 (-£22.27 to £6.67)
Nurse	1.75 (0.45)	1.68 (0.34)	£19.20 (£4.91)	£18.48 (£3.78)	-£0.71 (-£14.74 to £13.31)
Surgeon	1.05 (0.32)	0.62 (0.23)	£120.75 (£36.44)	£70.25 (£26.70)	-£50.03(-£143.72 to £43.67)
Hospital doctor	0.41 (0.15)	0.27 (0.13)	£54.68 (£20.62)	£36.45 (£17.48)	-£18.23(-£74.51 to £38.06)
Physiotherapist	2.32 (0.58)	0.94 (0.43)	£83.34 (£20.78)	£33.84 (£15.57)	-£49.5 (-£100.30 to £1.29)
Other	0.50 (0.20)	0.33 (0.15)	£32.10 (£12.94)	£21.19 (£9.48)	-£10.91 (-£43.05 to £21.22)
Inpatient Hospital Days					
Related to hip	0.66 (0.34)	0.37 (0.19)	£209.35 (£109.01)	£116.13 (£59.15)	-£93.22 (-£336.16 to £149.72)
Unrelated to hip	0.38 (0.16)	0.23 (0.14)	£131.20 (£56.40)	£79.75 (£48.69)	-£51.45 (-£232.07 to £129.17)
Equipment	Various	Various	£2.24 (£0.24)	£1.60 (£0.21)	-£0.64 (-£1.29 to -£0.0003)*
Total follow-on NHS Costs	--	--	**£704.58 (£186.97)**	**£504.36 (£104.26)**	**-£200.23 (-£655.50 to £255.05)**
Private Healthcare Visits To					
General Practitioner	0.05 (0.05)	0.03 (0.03)	£1.08 (£1.21)	£0.72 (£0.72)	-£0.36 (-£3.70 to £2.98)
Nurse	0.00 (0.00)	0.00 (0.00)	£0.00 (£0.00)	£0.00 (£0.00)	£0.00 (--)
Physiotherapist	1.13 (0.49)	1.01 (0.42)	£50.63 (£21.90)	£45.23 (£18.84)	-£5.40 (-£66.70 to £55.90)
Occupational Therapist	0.00 (0.00)	0.00 (0.00)	£0.00 (£0.00)	£0.00 (£0.00)	£0.00 (--)
Osteopath	0.27 (0.22)	0.26 (0.19)	£14.00 (£11.68)	£13.46 (£10.17)	-£0.53 (-£35.08 to £34.02)
Chiropractor	0.00 (0.00)	0.00 (0.00)	£0.00 (£0.00)	£0.00 (£0.00)	£0.00 (--)
Other	0.29 (0.21)	0.00 (0.00)	£10.44 (£7.62)	£0.00 (£0.00)	-£10.44 (-£25.85 to £4.97)
Total follow-on Private Costs	--	--	£76.14 (£32.43)	£59.41 (£23.90)	-£16.73 (-£102.43 to £68.97)

Acronyms: Confidence interval (CI), standard error (s.e.).

* p<0.05

† p<0.01

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Table 4. One-way sensitivity analysis results: Varying hospitalisation costs and levels of health related quality of life in the accelerated physiotherapy programme arm

Cost	Mean total costs	Incremental costs*	95% CI	
Standard physiotherapy	£704.58			
APP - Reference case	£504.36	-£200.22	-£655.50	to £255.05
APP Hospitalisations: +25%	£553.33	-£151.25	-£627.33	to £324.82
APP Hospitalisations: +50%	£602.30	-£102.28	-£601.29	to £396.72
APP Hospitalisations: +75%	£651.27	-£53.31	-£577.09	to £470.46
APP Hospitalisations: +100%	£700.24	-£4.34	-£554.48	to £545.79
HRQoL	**Mean total QALYs**	**Incremental QALYs†**	**95% CI**	
Standard physiotherapy	0.71			
APP - Reference case	0.84	0.13 QALY	0.05 QALY	to 0.20 QALY
APP QALY: -15%	0.71	0.0025 QALY	-0.07 QALY	to 0.07 QALY
APP QALY: -7.5%	0.78	0.07 QALY	-0.01 QALY	to 0.14 QALY
APP QALY: +7.5%	0.89	0.18 QALY	0.10 QALY	to 0.26 QALY
APP QALY: +15%	0.92	0.21 QALY	0.14 QALY	to 0.29 QALY

Acronyms: Confidence interval (CI), accelerated physiotherapy programme (APP), health related quality of life (HRQoL), quality adjusted life years (QALYs).

* Values calculated by taking the difference in costs between each specific scenario in the APP arm and the standard physiotherapy arm.

† Values calculated by taking the difference in QALYs between each specific scenario in the APP arm and the standard physiotherapy arm.

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Table 5. Two-way sensitivity analysis results: The probability that accelerated physiotherapy programme is cost–effective at a willingness to pay of £20,000 per quality adjusted life years for varying estimates of hospitalisation cost and health related quality of life.

	APP - Reference case	APP +25% hospitalisation	APP +50% hospitalisation	APP +75% hospitalisation	APP +100% hospitalisation
APP - Reference case	1.00	1.00	1.00	1.00	1.00
APP QALY: -15%	0.61	0.59	0.57	0.54	0.52
APP QALY: -7.5%	0.97	0.97	0.96	0.96	0.95
APP QALY: 7.5%	1.00	1.00	1.00	1.00	1.00
APP QALY: 15%	1.00	1.00	1.00	1.00	1.00

Acronyms: accelerated physiotherapy programme (APP), quality adjusted life years (QALY)

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Figure 1. Flow of participants

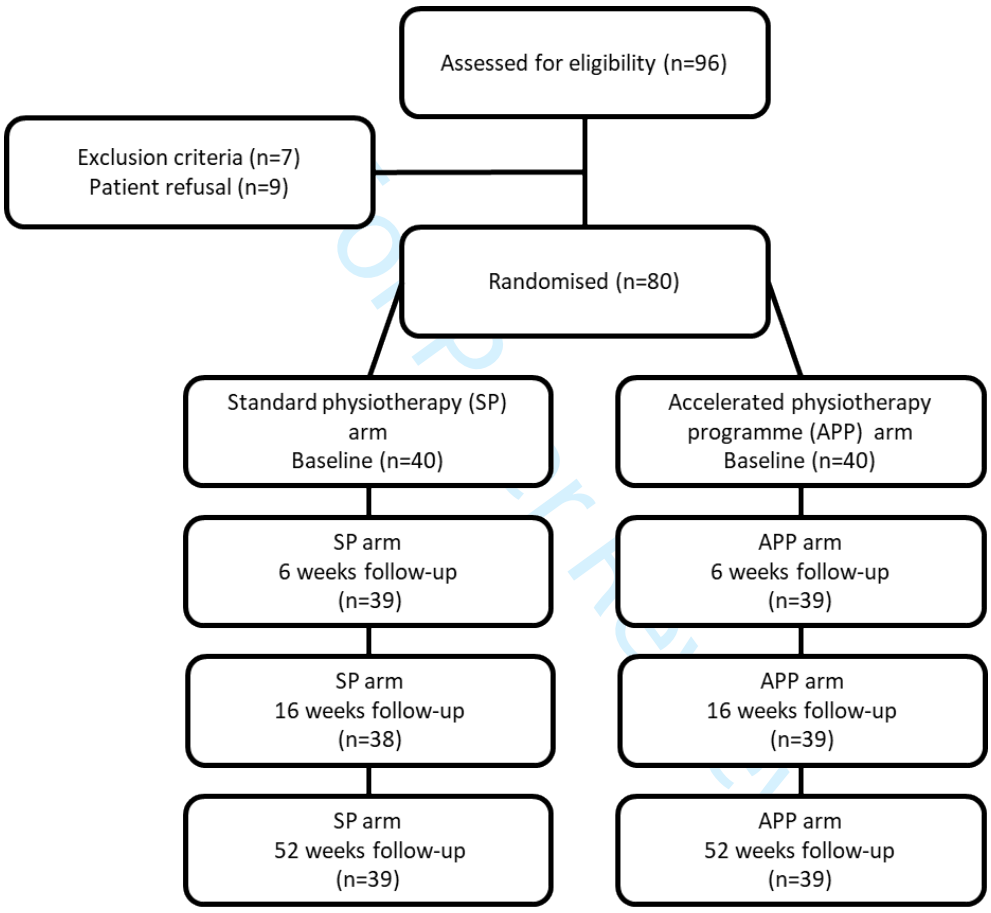


Figure 2. Mean EQ-5D utility scores and 95% confidence intervals by time point and trial arm.

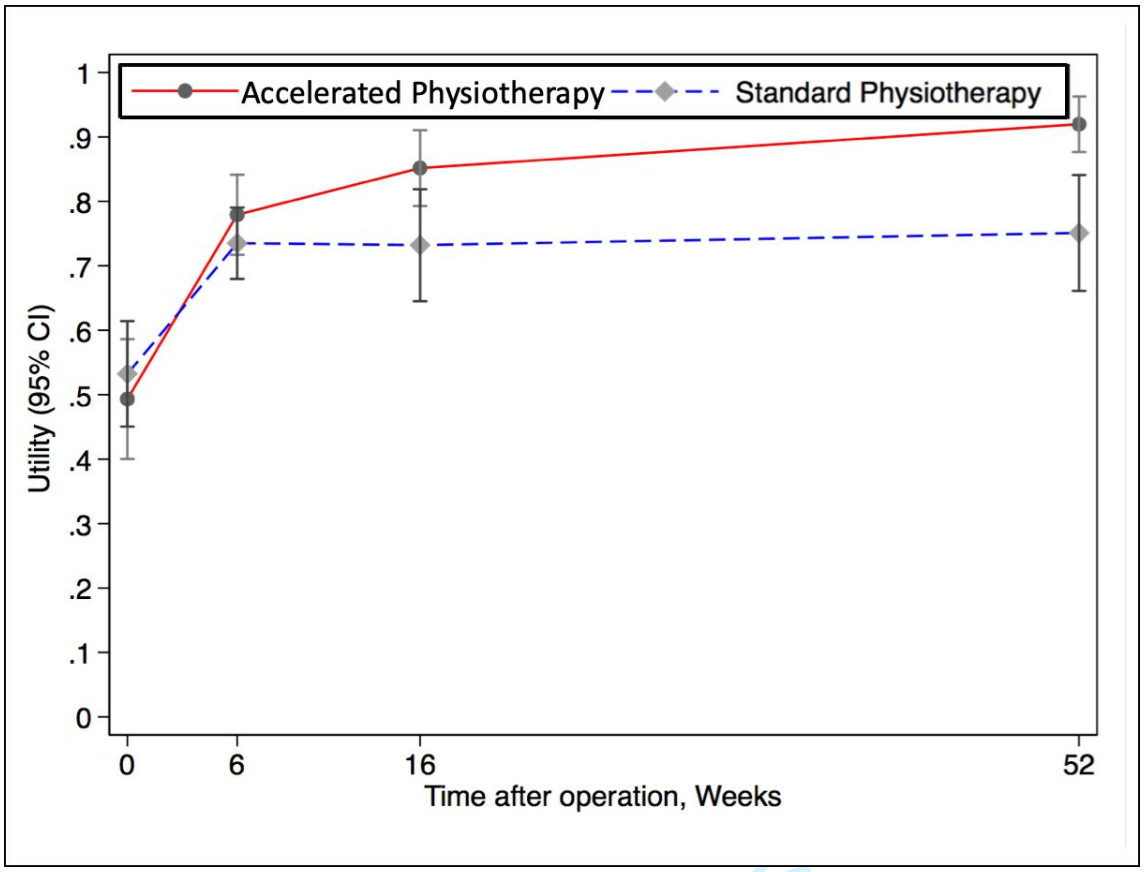


Figure 3. Cost-effectiveness plane showing 5000 bootstrapped pairs of cost and quality adjusted life year differences

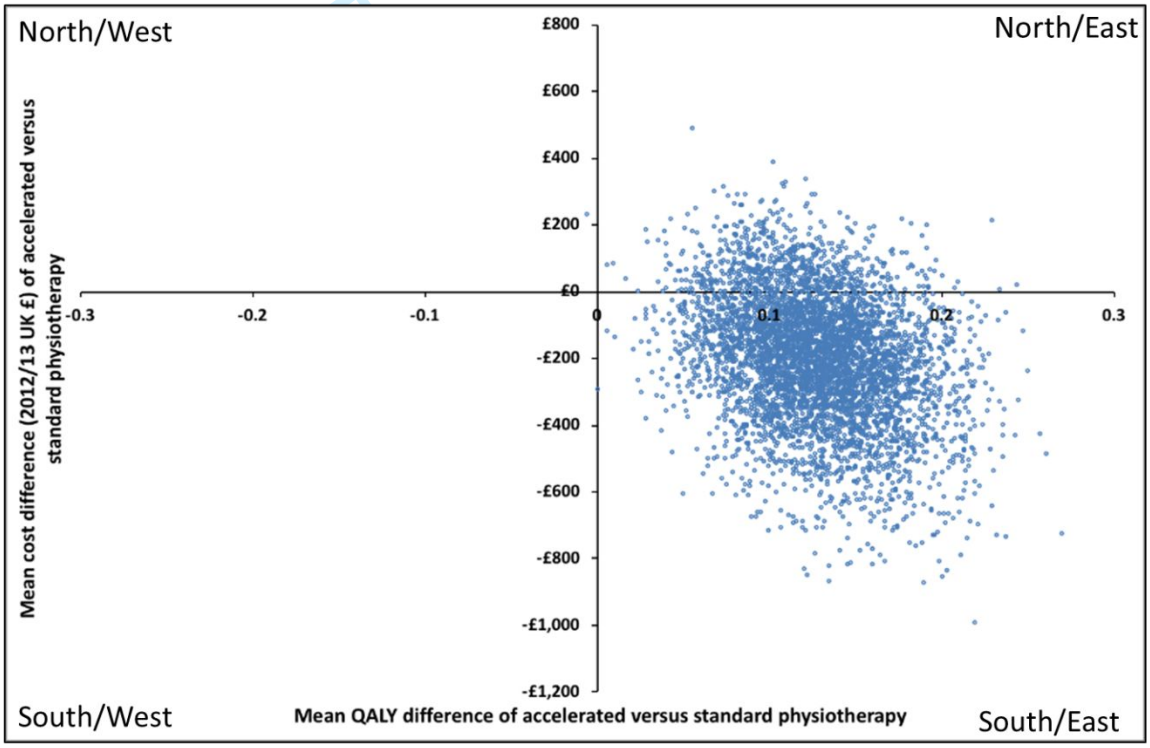
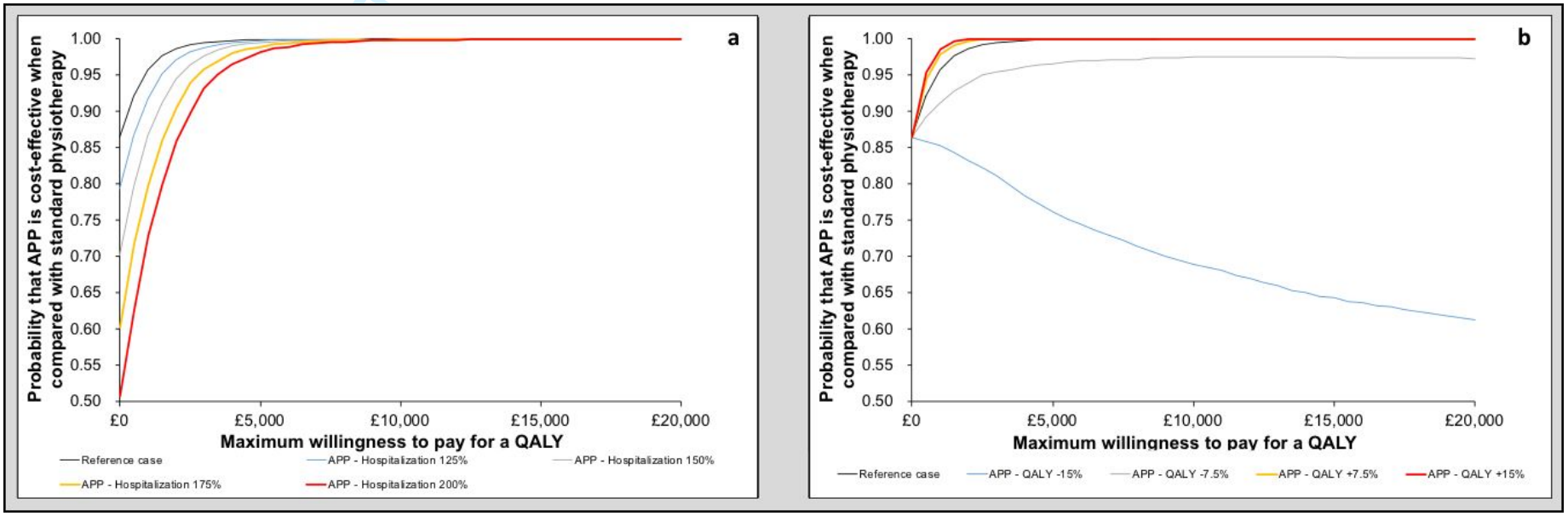


Figure 4. Cost-effectiveness acceptability curves: reference case and one-way sensitivity analyses varying hospitalisation cost (panel a) and quality adjusted life years (panel b) observed in accelerated physiotherapy programme arm.



Acronyms: accelerated physiotherapy programme (APP), quality adjusted life years (QALY)

CONSORT 2010 checklist for clinical trials

Section /Topic	Item No	Checklist Item	Reported on Page No
Title and abstract			
	1a	Identification as a randomised trial in the title	1
	1b	Structured summary of trial design, methods, results and conclusions (for specific guidance see CONSORT for abstracts)	2-3
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	5
	2b	Specific objectives or hypotheses	5
Methods			
Trial design	3a	Description of trial design(such as parallel, factorial) including allocation ratio	6
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	6
Participations	4a	Eligibility criteria for participants	6
	4b	Settings and locations where the data were collected	6
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	6-7
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6-9
	6b	Any changes to trial outcomes after the trial commenced, with reasons	6
Sample size	7a	How sample size was determined	6
	7b	When applicable, explanation of any interim analyses and stopping guidelines	6
Randomisation			
Sequence generation	8a	Method used to generate the random allocation sequence	6
	8b	Type of randomisation, details of any restriction (such as blocking and block size)	6
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	6
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	6
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	N/A
	11b	If relevant, description of the similarity of interventions	N/A
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	10-13
	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	12
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for primary outcome	14

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	13b	For each group, losses and exclusions after randomisation, together with reasons	14
Recruitment	14a	Dates defining the periods of recruitment and follow-up	6
	14b	Why the trial ended or was stopped	N/A
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	14
Number analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	16
Outcomes and estimation	17a	For each primary and secondary outcomes, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	15-17
	17b	For binary outcomes, presentation of both absolute and relative effect sizes in recommended	N/A
Ancillary analyses	18	Results of any other analyses perform, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	17-18
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms [28])	6
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	24-26
Generalisability	21	Generalisability (external validity, applicability) of trial findings	23-24
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	21-23
Other information			
Registration	23	Registration number and name of trial registry	3
Protocol	24	Where the full trial protocol can be accessed, if available	6
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	23

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CHEERS checklist—Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared.	P:1
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	P:2-3
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study.	P:5
		Present the study question and its relevance for health policy or practice decisions.	P:5
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	P:6
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	P:6
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	P:8
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	P:6-7
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	P:8-9
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate.	N/A
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed.	P:9-10
Measurement of effectiveness	11a	*Single study-based estimates:* Describe fully the design features of the single effectiveness study and why the single study was a sufficient source of clinical effectiveness data.	P:6-7, 17
	11b	*Synthesis-based estimates*: Describe fully the methods used for identification of included studies and synthesis of clinical effectiveness data.	N/A
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes.	P:9-10
Estimating resources and costs	13a	*Single study-based economic evaluation:*Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	P:8-9
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate	N/A

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Section/item	Item No	Recommendation	Reported on page No/ line No
		resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs.	
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate.	P:8
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended.	N/A
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model.	N/A
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty.	P:10-13
Results			
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended.	N/A
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	P: 15-19
Characterising uncertainty	20a	*Single study-based economic evaluation:*Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	P:19-21
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	N/A
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	N/A
Discussion			
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	P:21-22, 24-25,24
Other			
Source of funding	23	Describe how the study was funded and the role of	P:28

Section/item	Item No	Recommendation	Reported on page No/ line No
		the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	28

For consistency, the CHEERS statement checklist format is based on the format of the CONSORT statement checklist

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